What can we learn about gravity waves with Concordiasi ?

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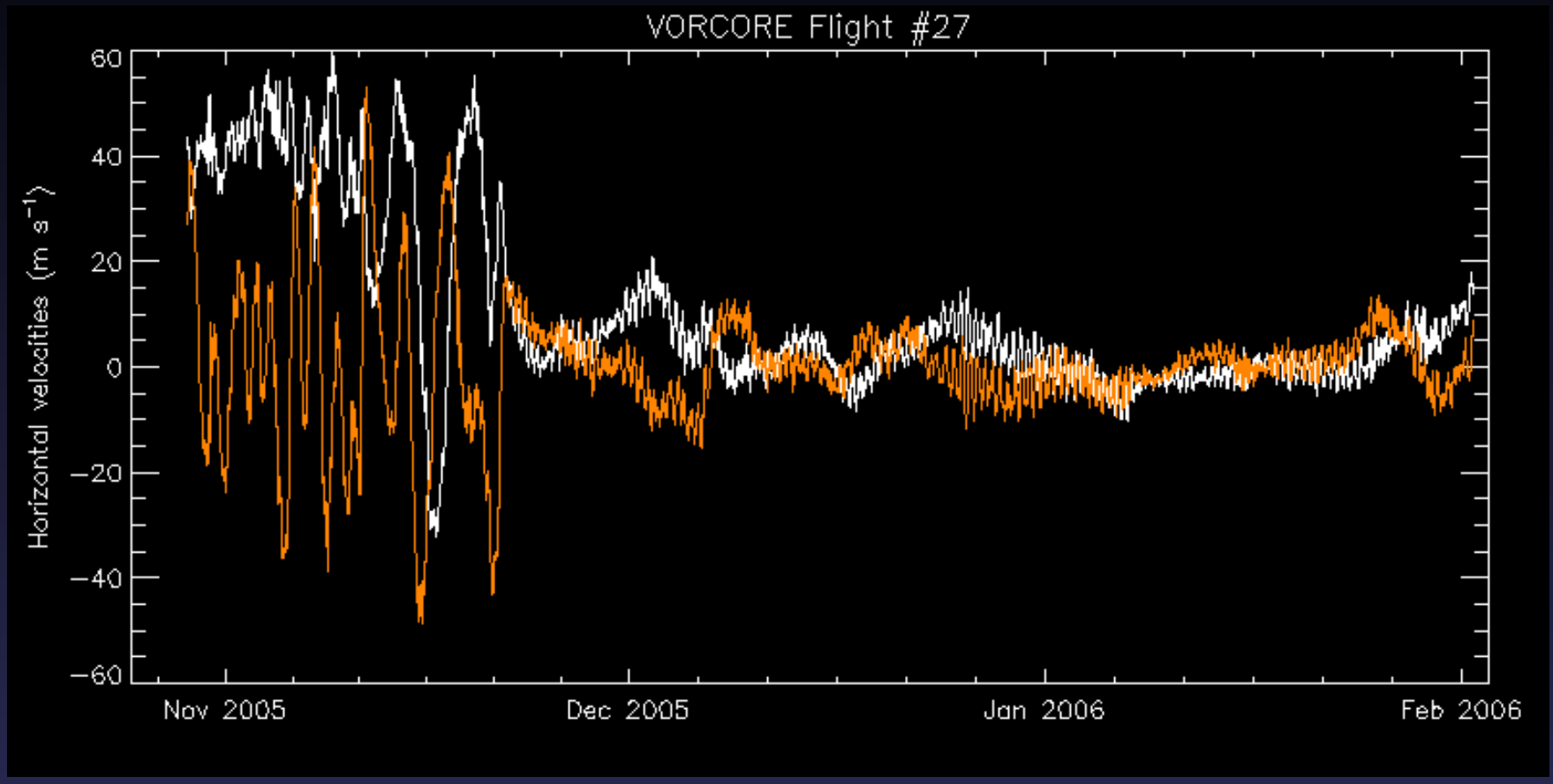
Short background

- Gravity waves are mesoscale motions (10-1000 km in the horizontal, 0.1-10 km in the vertical, minutes to hours)
- They are generated by a variety of (tropospheric) processes: flow over mountains, jets, fronts, convection, etc.
- They propagate vertically in the atmosphere and contribute to the driving of the Brewer-Dobson circulation in the middle atmosphere. They are particularly important in Antarctica, where they significantly heat the stratosphere.
- They are not explicitly resolved in climate models, so that their effect must be parameterized.
- They may trigger the formation of PSCs in the polar stratosphere.

GW studies with superpressure balloons

- Superpressure balloons are helpful devices to study GWs:
  - Long duration => obtain information on large areas, assess the global effect of GWs
  - Balloons are advected by the horizontal wind => direct access to the wave intrinsic frequency
  - Wind disturbances induced by the waves are easily accessed from the horizontal displacements of the balloon
  - Balloon drift on isopycnic surfaces, which vertical displacements can be related to those of isentropic surfaces (on which air parcels are moving)

Vorcore Observations

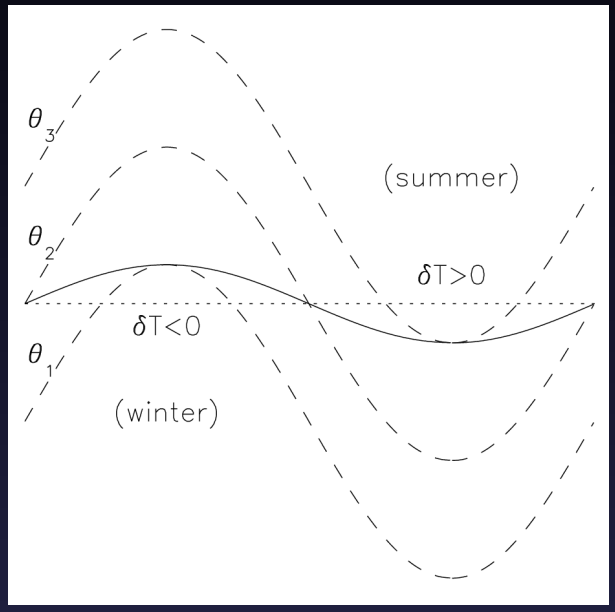


Balloon-borne estimation of gravity-wave momentum flux

- Lagrangian disturbance:

$$p'_l = p' + \zeta'_\rho \frac{\partial \overline{p}}{\partial z}$$

- The second term:
  - dominates
  - is linked to w'
  - is in quadrature with p'
  - so that, when forming the covariance with $u'_{/\!/}$ and using standard GW polarization relations



$$\overline{u'_{/\!/} w'} = -\frac{\hat{\omega} g}{\bar{\rho} N^2} \Im\left(p'_l u'_{/\!/}\right)$$

(Hertzog and Vial, 2001, Boccara et al, 2008)

Balloon-borne estimation of gravity-wave momentum flux

$$\overline{u'_{\parallel} w'} = -\frac{\hat{\omega} g}{\bar{\rho} N^2} \Im\left(p'_l u'_{\parallel}\right)$$

- A wavelet decomposition is performed on the timeseries of u, v, P

- The intrinsic frequency is directly obtained from the balloon timeseries, or from the wavelet decomposition

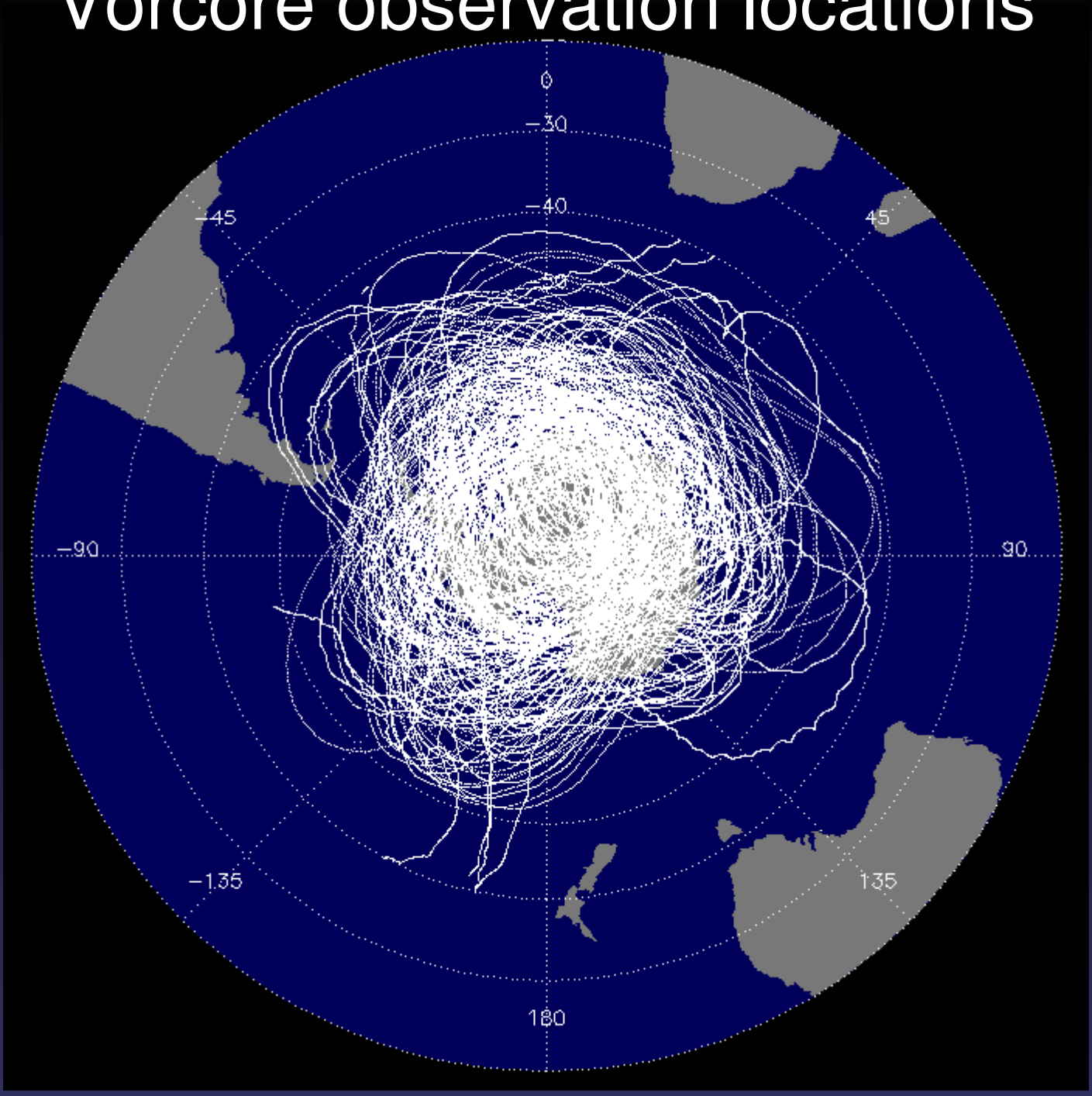
- The wave direction of propagation is obtained by rotating the horizontal frame of reference and maximizing the flux along the rotated x axis

Vorcore campaign
McMurdo, Antarctica, 2005

27 balloon flights
Launch: September 5 - October 28
Last balloon: February 1st, 2006

Mean duration: 58.5 days
Longest flights: 109 days
150,000 observations

Vorcore observation locations



Absolute momentum fluxes

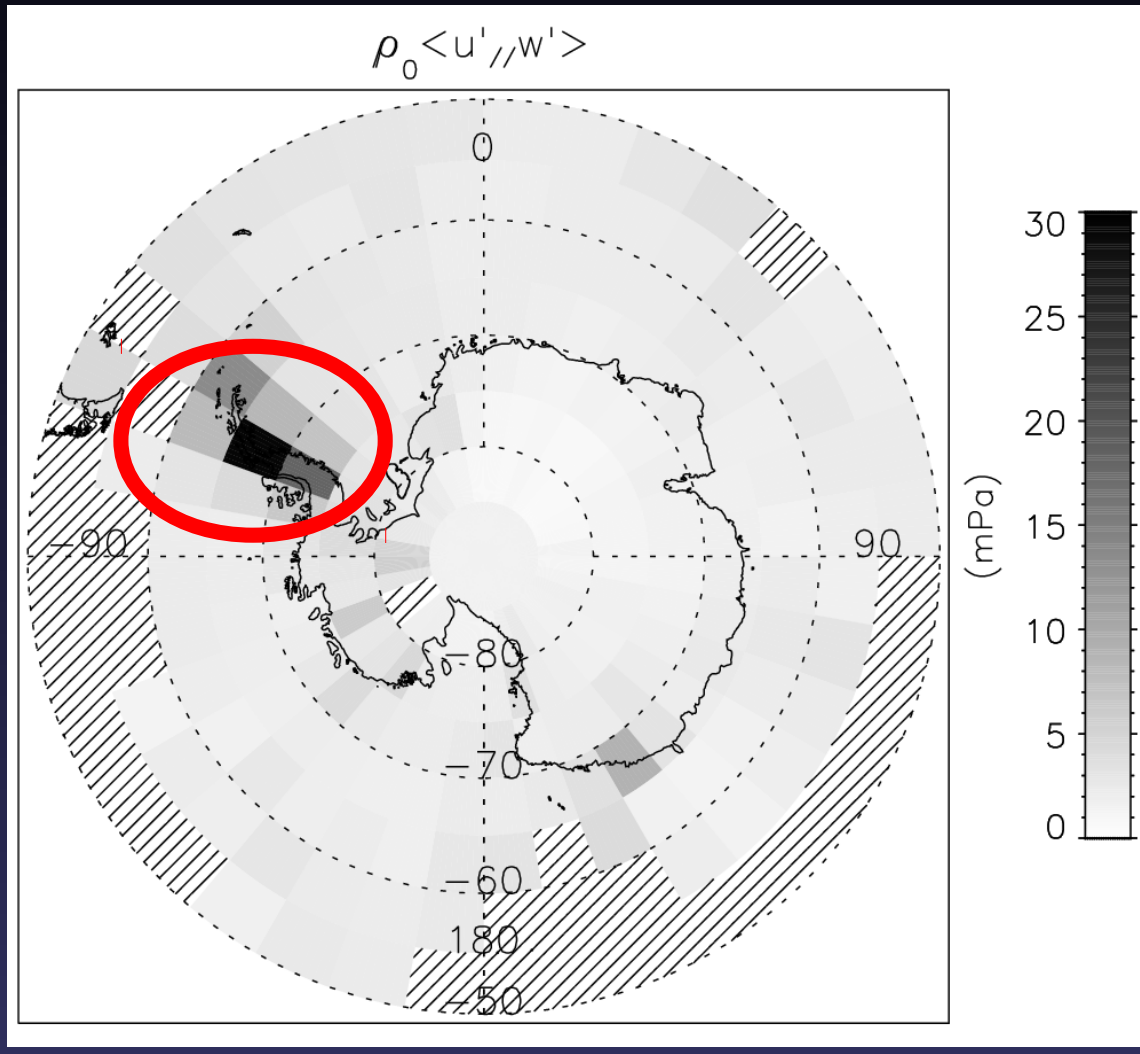
- $\rho_0 \langle u'_{\parallel} w' \rangle$ in 10°-5° longitude-latitude boxes

Overall mean: 2.5 mPa
(intrinsic period > 1h)

Peninsula mean > 25 mPa
Maximum values ~ 1 Pa

Larger values:
Western Antarctica,
Adélie Land

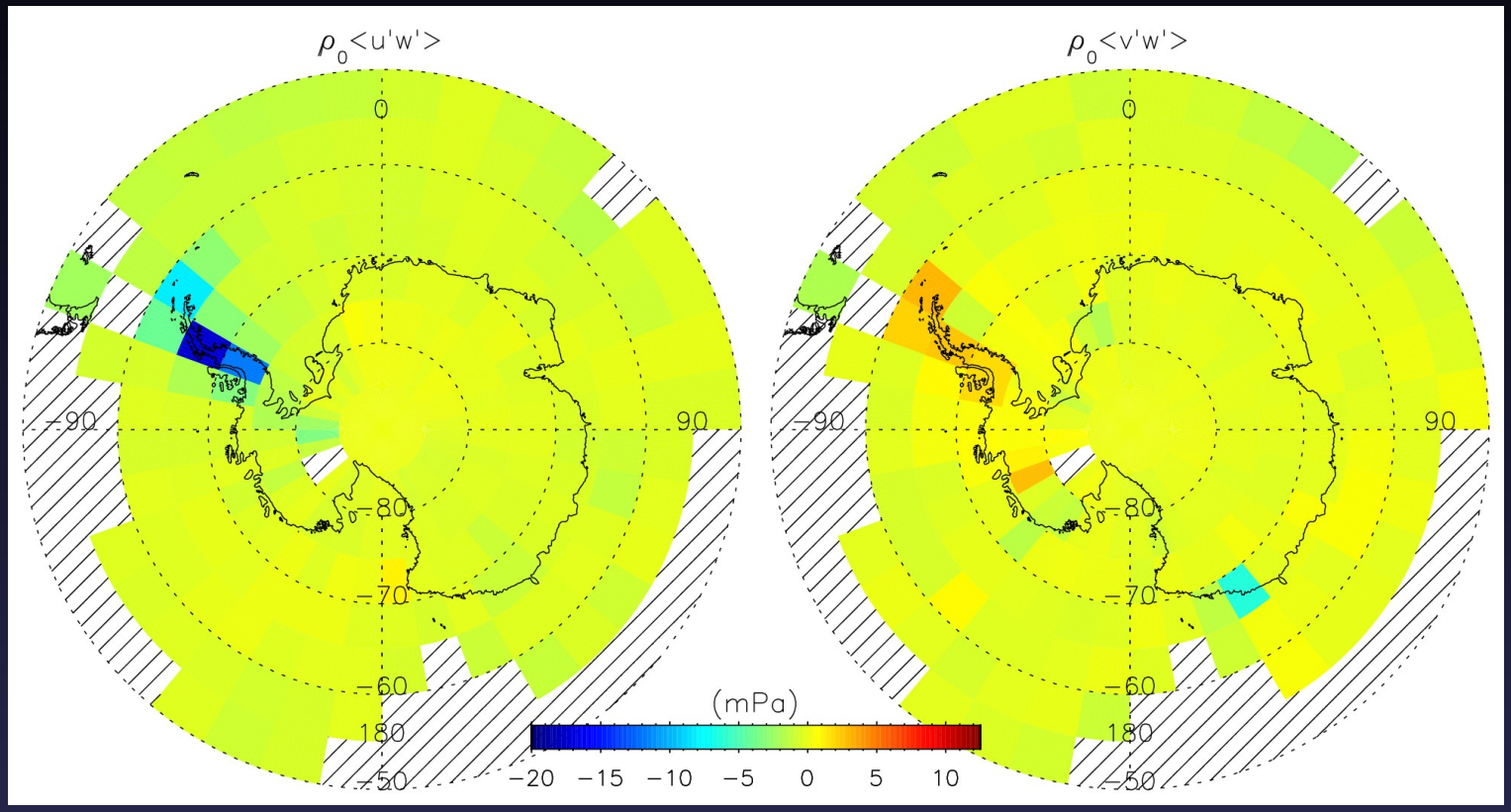
Non-zero values above
Atlantic and Indian Ocean



Directional momentum fluxes

Zonal

Meridional

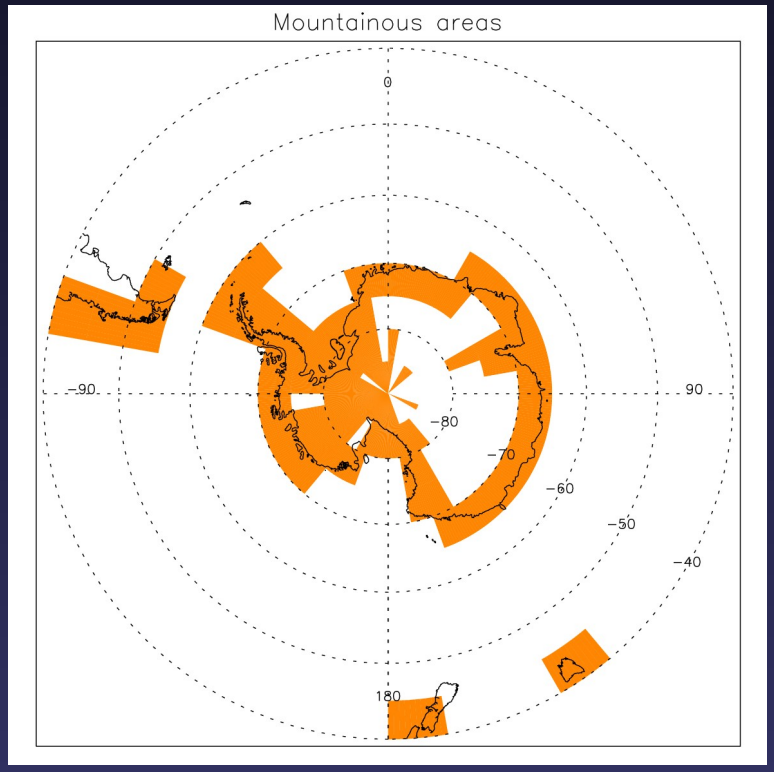


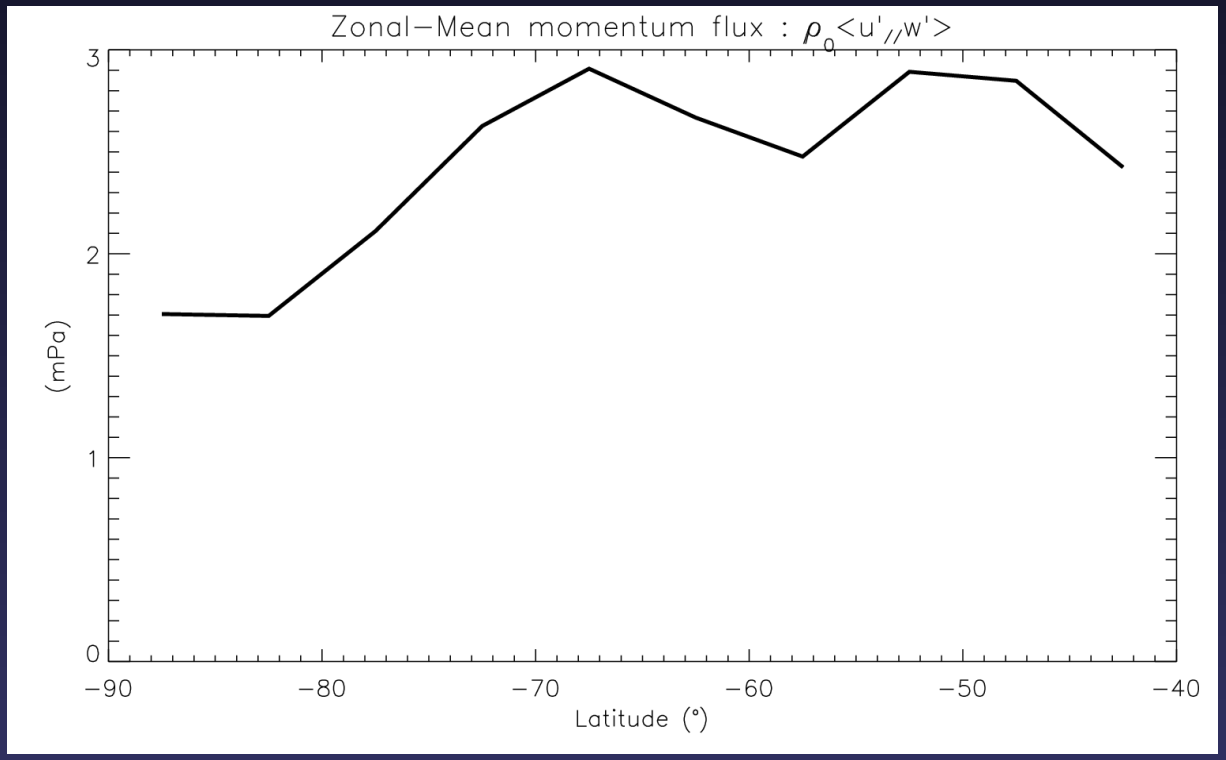
ρ_0<u'w'> negative almost everywhere (including Atlantic Ocean)

No net tendency on ρ_0<v'w'>

Orographic/Non-orographic waves

- Geographical criterion (based on topography gradients) to flag boxes as mountainous or non-mountainous
- Compute zonal-mean absolute fluxes and the contribution of both types of areas





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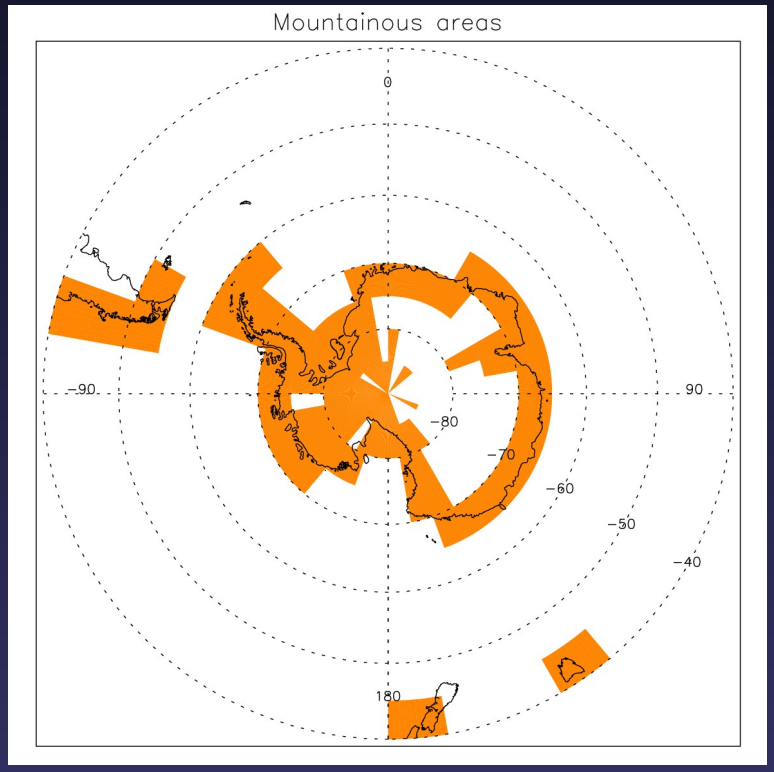

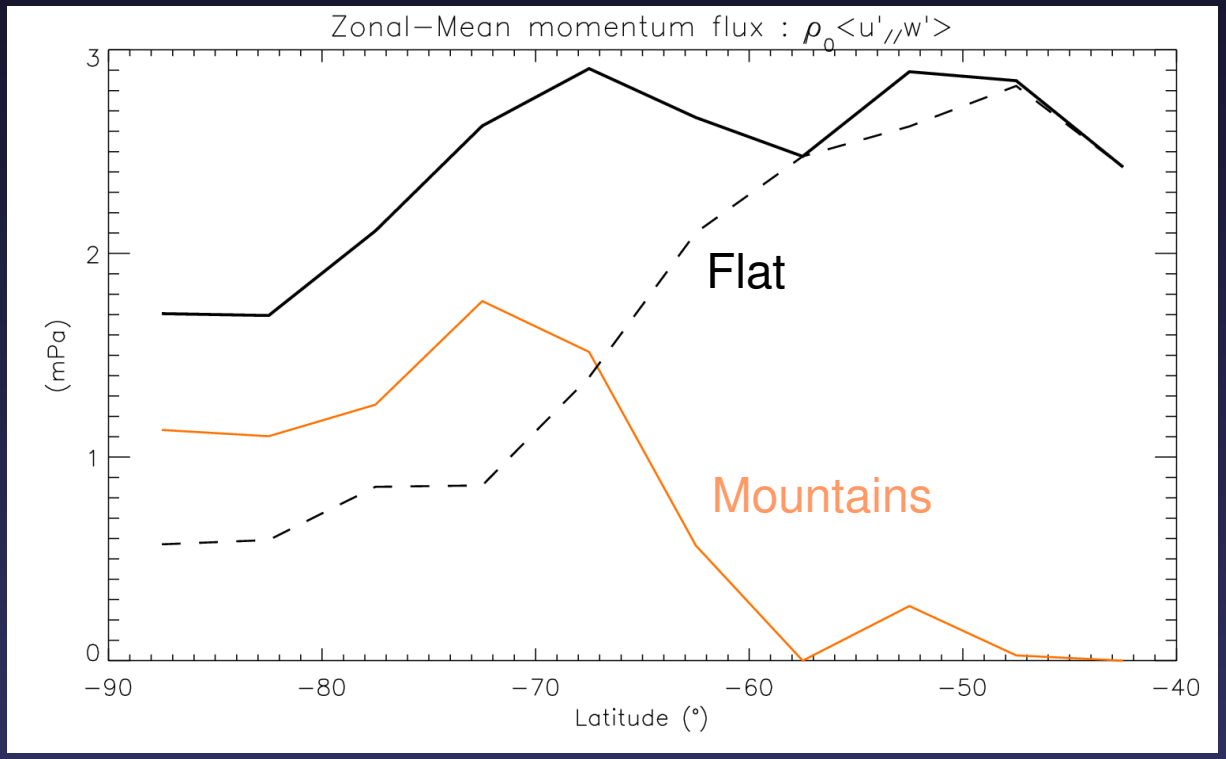

What's new with Concordiasi ?

- Higher accuracy on P, z_GPS => improve the accuracy of our estimates of momentum fluxes
- Higher sampling rate (30 s vs 15 min during Vorcore) => resolve the high-frequency part of the GW spectrum, which is expected to carry a significant part of the momentum flux
- Hopefully flights at lower latitudes than during Vorcore => address the generation of GWs above storm tracks
- Study the impact of mountain waves on the generation of ice particles, and possible NAT generation leeward of the mountains